Radiation Hormesis Notes

This presentation addresses the phenomenon of radiation hormesis – what it is, how it works, its validation from radiation exposure and cancer mortality observations, and the idealized dose-response curve for ionizing radiation.

Slide 3 – generalized hormesis curve

- graphic vertical axis indicates beneficial biological effect above normalized control response and adverse biological effect below control response
- graphic illustrates range of biological stressor low doses (hormetic zone) that benefits organism by uprating biological adaptive protective mechanisms
- threshold dose – biological response to stressor dose transitions from beneficial effect to adverse effect
- maximum response corresponds to optimum stressor dose

Slide 9 – dual effect of low dose ionizing radiation graphic

- applicable to physiological effects of <u>acute</u>, low-dose radiation in range of 0.01 to 0.5 Gy total absorbed dose
- biological adaptive protection neutralizes radiation-induced DNA damage for <u>acute</u> doses up to 0.2 Gy
  - numerous studies support finding that effect of radiation-induced adaptive protection outweighs damage from acute whole-body doses well below 0.2 Gy of low LET radiation
- 0.2 Gy effectively absorbed dose threshold for radiation-induced adverse health effects

Slide 12 – gamma-ray dose vs cancer mortality rate graphic

- areas of highest gamma-ray exposure also areas of lowest cancer mortality

Slide 13 – cosmic-ray exposure vs cancer mortality rate graphic

- areas of highest cosmic-ray exposure also areas of lowest cancer mortality

Slide 14 – U.S. annual cancer mortality rate vs natural background dose

- lower cancer mortality rate than U.S. average for 22 of 38 states with background dose < 2.7 mSv/y
- lower cancer mortality rate than U.S. average for 8 states with background dose > 2.7 mSv/y
- cancer mortality predictions based on LNT dose-response model show inapplicability of model to low dose/dose-rate radiation

Slide 15 – cancer mortality vs dose graphic

- graphic also shows inapplicability of LNT model to low dose radiation

- LNT model cancer mortality rate predictions from Biological Effects of Ionizing Radiation (BEIR) VII Report
- Data points associated with following studies
  - Taiwan – residents of Co-60 contaminated apartments in Taiwan
  - NSWS – Nuclear Shipyard Worker Study
  - British Radiologists – British Radiologists who entered service during the period 1955-1979
  - Mayak – Russian residents in villages near Mayak Nuclear Weapons Facility following 1957 radiation release accident

Slide 17 – idealized dose-response curve

- graphic illustrates idealized dose-response curve for chronic, whole-body radiation exposures
- beneficial effects of low radiation doses typically observed soon after initial exposure
- graphic shows adverse effects of increased rates of cancer associated with chronic dose rates >10 Gy/y (uniform dose-rate about 27 mGy/d)
- graphic shows optimum chronic dose-rate associated with minimal cancer death rate and maximal lifespan about 100 mGy/y (uniform dose-rate about 0.3 mGy/d)

Slide 20 – idealized dose-response curve (cont.)

- graphic shows another way to look at idealized dose-response curve for chronic, whole-body radiation exposures, with ambient dose being natural background radiation
- upper threshold of low dose region would be dose above natural background that produces same health effects as background radiation
  - doses below threshold would result in more beneficial health effects compared to effects attributable only to natural background
  - doses above threshold would result in detrimental health effects compared to natural background
- since worldwide annual natural background dose varies by as much as factor of 70 (e.g., Ramsar, Iran vs. areas of U.S.), upper threshold dose (or dose-rate) would likely be specified relative to highest background dose
- based on idealized dose-response curve numbers provided by T.D. Luckey, upper threshold dose-rate would be about 1 mGy per hour

Slide 21 – chronic dose characterization

- chronic radiation exposures < 100 rem over 12-month period (about 0.11 mGy/hr) will not increase risk of cancer or congenital defects – body's adaptive protection mechanisms not overwhelmed by chronic low dose radiation exposures

- threshold for increased risk of cancer or congenital defects consistent with the upper threshold dose rate of idealized dose-response curve (about 1 mGy/hr)

Slide 22 – acute dose characterization

- acute radiation doses < 20 rem (0.2 Gy) do not increase the risk of cancer or congenital defects – body's adaptive protection mechanisms not overwhelmed by acute radiation doses less than 20 rem
- $LD_{50/30}$ is acute dose that without treatment will be lethal to 50% of those exposed within 30 days

Slide 24 – reasonable radiation thresholds based on hormesis data

- chronic dose-rate threshold for reduced lifespan is point at which dose-rate begins to overwhelm body's adaptive protective mechanisms
- note that chronic exposure from natural background radiation includes both low LET and high LET (radon) radiation exposures, with inhaled radon contributing about 2/3 of U.S. background dose
- 30 μGy/h is reasonable assumption for high LET radiation high dose-rate threshold based on Ramsar, Iran natural background radiation exposure health effects data

Slide 25 – chronic exposures in perspective

- logarithmic scale of dose-rates given in microgray per hour so order-of-magnitude differences between normal low-dose-rate exposures and high-dose-rate threshold are obvious
- bottom line message – U.S. public chronic ionizing radiation exposures well below thresholds for potential lifespan shortening